

SUGAR BEET DISEASES

And Their Control In Montana

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DEPARTMENT OF BOTANY AND BACTERIOLOGY



18 TONS

DISEASE CONTROL AND GOOD CULTURE PAYS

7 TONS

MONTANA STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
BOZEMAN, MONTANA

SUGAR BEET DISEASES AND THEIR CONTROL IN MONTANA

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INTRODUCTION

Sugar beets are one of Montana's important cash crops on irrigated land. The maximum acreage of this crop was 86,000 acres in 1940 and Montana ranked third in the United States in the production of sugar beets. This large acreage is due in a large measure to the adaptibility of the crop to the heavy soils, and the climatic conditions existing in the lower irrigated valleys of the State. Sugar beet factories are now located at Billings, Chinook, Missoula, Sidney and Hardin. The 1940 acreage by districts was approximately as follows: Billings 28,000, Chinook 15,000, Missoula 12,000, Sidney 19,000, and Hardin 12,000.

Sugar beets in Montana escaped serious injury from parasitic diseases and physiological troubles or deficiencies for many years, but at the present time certain of these diseases are becoming factors of great economic importance. It is the purpose of this bulletin to describe these troubles in such a way that the grower may recognize them, and to offer recommendations for their satisfactory economical control.

SEEDLING DISEASES OR "BLACK ROOT" OF SUGAR BEETS

Seedling diseases or root rots of young beets have considerable importance in the growing of sugar beets, especially on the heavy irrigated soils in Montana. Young beet seedlings are usually attacked by different pathogenic organisms either at the time when they emerge from the seed balls or later when they have emerged above ground.

Seedling diseases of sugar beets are of a complex nature and often several organisms may be responsible for the disease. A slight difference in soil composition, its temperature and other factors may be responsible for variation in the pathogens responsible for these diseases. There are several types of sugar beet seedling diseases occurring in Montana but the most typical one is characterized by a browning and blackening of the hypocotyl and root (figure 1) and this discoloration usually extends above the ground. The killing of the seedlings varies from fairly rapid to very slow and a plant may frequently show its hypocotyl

completely blackened, but its cotyledons remaining turgid and green for a long time. *Phoma betae* and some phycomycetous fungi are associated with this type of seedling disease of sugar beets.

Sugar beet seedlings up to the six-leaf stage have very little resistance against root rots, but after this stage those beets which survive usually become more resistant and many of them recover. However, the diseased beets which recover usually produce small and often discolored roots carrying scars of old infections. It is evident that seedling diseases damage beets not only through the reduction of the stand but also to a considerable extent in delaying the development of the beets because of the injuries sustained in their early stage of development.



Figure 1. Seedling disease of sugar beets. Left, four diseased seedlings. Right, two healthy seedlings.

Numerous investigations were conducted by the authors on the nature and control of seedling diseases of sugar beets in which seed treatment, soil treatments, crops preceding the sugar beets, and temperature and moisture were studied in relation to the occurrence and control of seedling diseases of sugar beets. The results obtained from these studies are summarized in the following paragraphs.

1. SEED TREATMENTS.—In the tests conducted in heavy soils at the Huntley Field Station seed treatments were found to be only slightly beneficial in controlling seedling diseases of sugar beets. In these treatments basic copper sulphate (54 percent of metallic copper) 3 ounces, or Ceresan, 4 ounces, or New Improved

Ceresan, 1 ounce, was used per bushel of seeds (20 pounds). Negative results with seed treatments in clay soils of Ohio and Michigan have been reported, but in the lighter soils of Minnesota and Iowa beneficial effects have been obtained. It is evident that under certain conditions seed treatments are of importance in controlling seedling diseases of sugar beets. The recommended treatment where advocated for sugar beet seed is 1 to 1½ ounces New Improved Ceresan or 3 to 4 ounces Ceresan per bushel of seed.

2. SOIL TREATMENTS WITH FERTILIZERS.—Soil treatments with fertilizers were found to be of great importance in the control

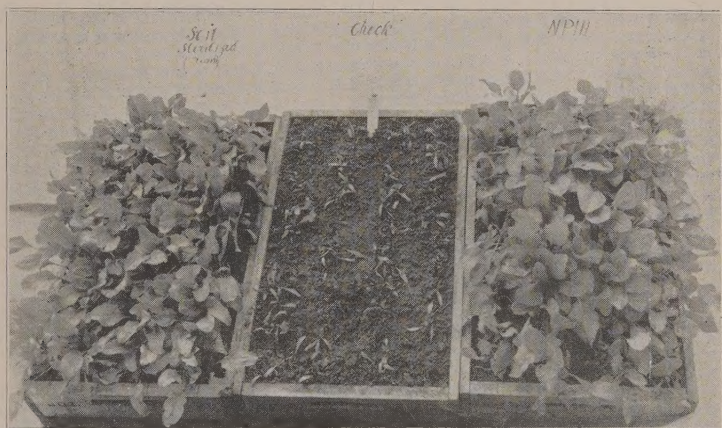


Figure 2. Effect of soil treatment on control of seedling diseases of sugar beets. Left, soil sterilized (steam). Center, untreated soil (check). Right, soil fertilized with manure, phosphorus and nitrogen.

of seedling diseases of sugar beets in heavy irrigated soils in Montana (figures 2 and 3). Sugar beets planted in soil well fertilized with manure and phosphorus in the fall and supplemented in the spring with nitrogen (in the form of artificial fertilizers) always had only a small amount of seedling diseases as compared to a much larger amount which occurred in beets grown in soil poor in nutrients.

These results show that supplying readily available plant food to young beets when they are becoming established and their food-absorbing root system is small appears to be the most significant factor in making the plant more resistant to the invasion of either soil or seed-borne pathogens.

Proper fertilization is important not only in controlling seedling diseases of sugar beets, but also in obtaining the maximum possible yield under given environmental conditions. As an illustration the results of the soil treatment experiment conducted at the Huntley Field Station in 1939 and 1940 can be cited. Soil which was used in this experiment was very depleted in organic material and mineral nutrients, and a high amount of seedling diseases of sugar beets always occurred. Plots which received complete fertilization (composed of 14.75 tons of manure applied in the fall, and 250 pounds of calcium nitrate and 175 pounds of treble superphosphate applied in the spring per acre of soil) in 1939, had only 30.7 percent diseased beet seedlings and produced 15.1 tons of beets. The same plots also received in 1940, 22 tons of manure and the above mentioned amounts of calcium nitrate



Figure 3. Effect of soil treatment on control of seedling diseases of sugar beets. Left, soil fertilized with phosphorus. Center, soil fertilized with nitrogen and phosphorus. Right, soil fertilized with nitrogen.

and treble superphosphate, and had only 21.8 percent of diseased seedlings and produced a yield of 18.23 tons of beets. During 1939 and 1940 the check plots had 75.0 percent of diseased seedlings and produced only 6.1 tons and 7.47 tons of beets. The plots which received incomplete soil fertilization in the form of either phosphates alone or nitrates or manure had a high amount of diseased seedlings and considerably lower yields than the plots which received complete soil fertilization.

In an experiment conducted in the greenhouse using heavy soil (Huntley Field Station) it was found that when calcium nitrate and treble superphosphate were applied, the amount of seedling diseases was less than when ammonium sulphate and treble superphosphate were used. Nutrition of young beets is very localized and is dependent on easily available nutrients, especially nitrates. Time and certain favorable environmental conditions are necessary before nitrogen applied in the form of ammonium salts becomes available to sugar beets. This period may be quite critical in making plants more or less resistant or susceptible to seedling diseases.

3. PRECEDING CROPS.—It is a well known fact that preceding crops exert their influence on succeeding crops. The effect of several preceding crops on the amount of seedling diseases of beets in heavy soil where alfalfa was grown for three years under irrigation was investigated. It was found that the lowest amount of beet seedling diseases occurred when the beets were planted after corn and the highest when beets followed beets. The diseases occurred in increasing amounts when they were planted after corn, potatoes, oats, alfalfa, beans and beets. The amount of seedling diseases of sugar beets planted after different preceding crops undoubtedly will vary, depending on the type of soil used and climatic conditions prevailing during decomposition in the soil of the remnants of preceding crops.

Unfavorable effects of some of the preceding crops on seedling diseases of sugar beets can be eliminated by proper fertilization of the soil. Heavy soil (Huntley Field Station) in which alfalfa was grown for three consecutive years under irrigation and where each year practically all beet seedlings perished because of "black root" was benefited to such an extent by proper fertilization with manure, phosphates and some nitrogenous fertilizers that a stand of healthy and vigorous seedlings was obtained.

4. TEMPERATURE AND MOISTURE.—Environment has a great influence on the occurrence and development of seedling diseases of sugar beets. To obtain definite information on this subject, investigations were conducted in which the effect of temperature and moisture on the amount of seedling diseases of beets was studied in heavy soils under controlled conditions. This problem was studied at five different temperatures, 10°C. (50°F.), 15°C. (59°F.), 20°C. (68°F.), 25°C. (77°F.) and 30°C. (86°F.) at three different soil moistures: maximum (85 percent of saturation), optimum (65 percent of saturation) and minimum (50 percent of saturation).

The results of this study show that low temperatures (10°C.=50°F.) and a minimum of moisture are more favorable to sugar beets from the standpoint of freedom from seedling dis-

eases than high temperatures and high moisture. Even at the maximum and optimum of moisture, seedling diseases were relatively small at low temperatures, and increased considerably with high temperatures. These results support the recommendation of early planting of sugar beets when temperatures are still low, to avoid a high amount of seedling diseases which may appear at higher temperatures in later plantings.

5. SEGMENTED SEEDS.—There are some indications that beets planted with segmented seeds have less seedling disease than those planted with whole seeds. The high amount of seedling disease in beets planted with whole seeds is probably due to their crowding and competition.

6. CULTIVATION.—Seedling diseases of beets are less prevalent on well drained soils. Cultivation of soil as soon as the drill rows can be followed does much to lessen damage.

7. SELECTIVE THINNING.—When seedling diseases are serious, it is very important that thinning of beets be delayed beyond the six-leaf stage when they usually become more resistant. In delayed thinning the healthy seedlings can be easily distinguished from stunted diseased plants so that selective thinning leave the strongest healthiest beets may be practiced.

8. SUMMARY OF CONTROL OF SEEDLING DISEASES.—Seed treatment is of doubtful benefit in Montana, but high fertility properly balanced and good physical condition of soil are of utmost importance. Preceding crops influence the amounts of disease. It is best to plant beets early, and beets planted with segmented seeds usually have less disease than those planted with whole seeds. Cultivate to break the soil crust. When disease is abundant, delay thinning beyond the six-leaf stage.

PHOSPHORUS AND NITROGEN DEFICIENCIES IN SUGAR BEETS

Sugar beets require a considerable amount of readily available phosphorus and nitrogen for their full development. Many of the beet fields are not producing satisfactory yields in irrigated valleys in Montana because there is a shortage of one or both of these plant nutrients. It is important that certain deficiencies be recognized and that measures be taken to remedy them.

A slight deficiency of available phosphorus may not produce symptoms in sugar beets that are readily recognized, although the best roots are small, the yield low, and the tops remain green up to harvest. The weight of sugar beet tops is unproportionally high as compared to the roots. An optimal ratio of weight of tops to roots of sugar beets at the time of harvest is usually considered to be 35 to 40 percent for tops and 60 to 65 percent for roots. In

case of a severe phosphorus deficiency in the soil, necrotic spots will appear in July or August, either on the edges of the sugar beet leaves or between the veins (figure 4). These spots enlarge and their color changes from light to dark brown and finally to black. In severe cases many spots coalesce and finally the whole leaf assumes the form of a crescent with upward curling and with the tissue of the leaf practically black and dry like parchment. This blackening of the leaves gradually progresses downward and the petioles become black and dead. The veins and petioles usually retain their green color longer than the interveinal tissue. The beet root itself usually remains unaffected unless some molds start to decay the petioles and this decay progresses into the sugar beet root. If all the leaves of a sugar beet are killed a considerable time before harvest, the root usually becomes soft and may decay due to infection with different rot-producing soil organisms.

The development of the symptoms of phosphorus deficiency of sugar beets is believed to be due not only to the amount of available phosphorus present in the soil, but also to the amount of available nitrogen. Sugar beets planted in soils which are poorly supplied with both these nutrients in the proper ratio to one another, usually do not develop symptoms of phosphorus deficiency. However, beets planted in soils which have sufficient nitrogen but are very low in phosphorus usually develop these symptoms, because plants well supplied with nitrogen require proportionally a high amount of phosphorus.



Figure 4. Symptoms of phosphate deficiency of sugar beet. (Courtesy Great Western Sugar Company)

Sugar beets on land previously cropped to alfalfa for several years often develop acute symptoms of phosphorus deficiency. The nitrogen content of the ground is maintained during the growth of the alfalfa, but the available phosphorus is materially reduced, and this tends to unbalance the ratio between nitrogen and phosphorus as compared to non-leguminous crops. Studies conducted in the rotations at the Huntley Field Station show that sugar beets planted either directly after several years of alfalfa or even with one intermediate crop often show severe symptoms of phosphorus deficiency. The soils of these rotations in which alfalfa was grown for several years are found deficient in available phosphorus and also in nitrates during the spring and early summer. This is probably due to certain climatic conditions and prevailing cultural practices. In preparing old alfalfa ground for

the next crop the following procedure usually was used. After removing the third alfalfa crop in the latter part of September, the alfalfa stubble was crowned and after 3 to 4 weeks, as soon as the crowns dried out, the field was plowed. Under conditions of dry weather in the fall and hard frost in the winter, most of the alfalfa crowns and roots overwinter in the soil without much decomposition. The main decomposition of alfalfa remnants begins only with moist, warm spring weather which closely coincides with the germination and growth of sugar beet seedlings. At that time most of the nitrogen is present in the form of organic compounds in the alfalfa remnants, the decomposition of which is only beginning. Young sugar beets require a considerable amount of nitrogen in their early stages of development and a deficiency of nitrates in the soil makes the seedlings grow slowly and become susceptible to diseases. However, later on in the season, when nitrogen from the alfalfa remnants becomes available, the beets which survive seedling diseases have proportionally more nitrogen than phosphorus for their nutrition. With the beginning of intensive growth of the root, sometime in July, the requirements of beets for phosphorus increases, and beets suffer from lack of this element and begin to show symptoms of phosphorus deficiency. This undoubtedly is due to phosphorus deficiency in the soil and especially to an unbalanced ratio between the very low amount of available phosphorus and the surplus of nitrogen.

The results of studies conducted at Huntley Field Station verify this as shown by the fact that beet rotations with alfalfa always showed more symptoms of phosphorus deficiency than those in continuous beets or in 2 or 3-year rotations which have a very low amount of available phosphorus and nitrogen in the soil as indicated by low yields. This unbalanced nutrition of sugar beets in the rotations with alfalfa is also indicated by upproportionally large development of the tops as compared to the roots.

It is believed that the ratio of tops to roots in sugar beets is a very important indicator of the fertility level of the soil in which beets are grown. An excess of nitrogen over phosphorus will support a greater development of tops as compared with roots and an excess of phosphorus over nitrogen will support a greater development of roots as compared with the tops. So in analysing the ratio of tops to roots of sugar beets, it is possible to draw conclusions concerning deficiency or surplus of nitrogen and phosphorus in the soil.

To correct soil deficiencies in old alfalfa ground the second cutting should preferably be plowed under in midsummer and then irrigated to favor decomposition of alfalfa remnants during the current season to make nutrients present in these remnants

available for the next crop. The field should be adequately fertilized with phosphorus before the alfalfa is plowed to replenish the amount removed from the soil by the alfalfa hay.

Phosphorus deficiency has been mentioned in many publications as "**black heart.**" The name "**phosphorus deficiency**" is preferred.

There are also many degrees of nitrogen deficiency in sugar beets. A slight deficiency may cause a somewhat early yellowing of the tops, whereas a severe shortage will cause yellowing very early in the season. The result of severe deficiency will be small tops, low yield of roots and no significant response to a phosphate fertilizer. The top-to-root ratio may be as low as 20 percent for tops and 80 percent for roots. It should be remembered that without good leaves it is impossible to have good roots. Experiments show that a liberal application of manure, supplemented by nitrogenous fertilizers will correct this deficiency in beets. When a considerable amount of nitrogenous fertilizer is applied, phosphorus also should be used; otherwise the nutrition of beets will be unbalanced.

SUGAR BEET YELLOWS (*Fusarium* Wilt)

This disease is caused by the soil fungus, called *Fusarium conglutinans* Wr. v. *betae* Stewart. It usually appears in July at which time the large sugar beet leaves begin to show yellowing of the portions of the leaf blade between the large veins (figures

5 and 6). Very often only one-half of the leaf blade is affected and the other half remains normal. In this case the leaves tend to twist at their apex to one side and become crescent shaped. The large veins and a narrow border of the leaf usually remain green longer than the other tissue of the leaf, but finally the whole leaf dies. Dead or dying older leaves become heaped around the crown of the diseased plant. The inner, younger leaves at the beginning of the disease usually show a distortion in the form of



Figure 5. Sugar beet yellows.

an inrolling of the edges and twisting of the apex to one side. Soon the young leaves also become yellow and die. Diseased leaves appear brittle and dry and are practically never wilted. In the last stage of this disease the tops of the beets, because of drying and breaking off, disappear and the crowns of the diseased beets stick through the ground with the remains of leaf petioles.

A root of a diseased plant very often does not show any external symptoms of a disease. If a root is cut across it shows a grayish to brown discoloration and rot of the vascular system. Often only a portion of the vascular tissue of the root is involved. This explains why only one side of a leaf shows yellowing and distortion. Sooner or later the fungus spreads through all or most of the vascular tissue of the root.



Figure 6. Sugar beet yellows in field.

This disease usually occurs in wet soils and produces a dry rot but very often at the lower end of the roots, infected beets show a wet rot which is probably due to secondary invaders.

Losses from this disease are due to a reduction of stand and lower the sugar content of diseased beets. Analyses of slightly infected sugar beets collected at harvest time showed that they contain approximately only 12 percent of sugar, when healthy beets had from 16 to 20 percent.

The only practical control for this disease is crop rotation.

Beets should be planted on the same land but once in 4 to 5 years. During the study of this disease at the Huntley Field Station it was found that the disease always occurred in the plot with continuous beets and also in 2- and 3-year rotations. In some of these plots there were more than 10 percent of beets infected with this disease. Sugar beets planted in 4- or 6-year rotations with, respectively, 2 or 3 years of alfalfa were practically free of yellows.

LEAF SPOT

Leaf spot is one of the best known and most widely distributed diseases of the sugar beet. This disease has been present in the beet districts of Montana for many years, but it has caused economic losses only occasionally in rather limited areas.

The disease is caused by a fungus (*Cercospora beticola* Sacc.), which penetrates the tissues of the leaf and leaf stem causing diseased spots. The sugar of the beet is made in the leaves, therefore any appreciable injury to the leaf will reduce the sugar content of the beet root.

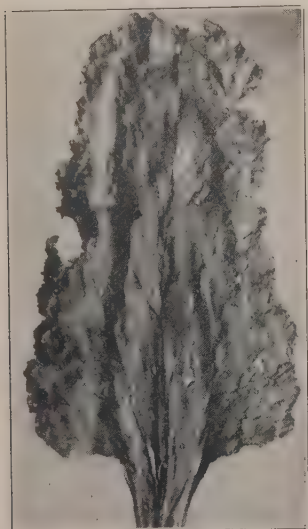


Figure 7. Leaf spot.

The first symptoms of this disease are very small, white to purple spots with a dark border which appear on leaf blade or petiole (figure 7). These gradually enlarge and become gray in the center. The outer or older leaves are attacked first, and then the disease gradually spreads to adjacent leaves until all leaves except the youngest center leaves are diseased. The beet plant is rarely killed by the disease although it may be seriously injured. In cases of severe infection many of the older leaves turn yellow and gradually die, but newer leaves are formed at the center of the crowns at the expense of the root. These new leaves tend to elongate the crown which causes an increased loss in topping the harvested beets.

This disease usually appears during the last half of the growing season as warm weather and relatively high humidity favor the development of the fungus.

The leaf-spot fungus lives over winter principally on beet refuse (fragments of leaves and leaf petioles) left in the field.

This is the main source of infection in the spring, as the spores produced on the refuse are carried by the wind and other agencies to the growing beet leaves, where they germinate and grow, causing diseased spots. The disease is also spread to a lesser extent by the fungus spores adhering on the surface of the seed balls.

The most satisfactory control methods are deep fall-plowing, crop rotation, spraying or dusting, and the use of resistant varieties. Crop rotation to eliminate danger from diseased tops of the previous crop is the most important control measure. If beets are to follow beets, a deep fall-plowing is a wise precaution. Spraying* with bordeaux mixture, or dusting* with monohydrated copper sulphate or some of the fixed copper compounds has proved successful and economical in certain years in various sugar beet areas in which the disease has occurred in an epidemic form.

In the breeding program, varieties of sugar beets resistant to leaf spot are being sought, and considerable progress has been made. No leaf spot-resistant variety has yet been found which can replace the present commercial varieties.

RHIZOCTONIA ROT

This disease is caused by the soil fungus *Rhizoctonia solani* Burt. Sugar beets infected with *Rhizoctonia* begin to show a blackening of the petioles of the outer leaves in the middle of the summer and these leaves often, when still green, fall to the ground and later turn brown. If the disease is severe all leaves of the plants are usually killed. The crown of the beet root when severely infected usually has many brown to dark-brown cracks, and dark-brown mycelium of *Rhizoctonia* usually can be found in them (figures 8 and 9). With favorable growth conditions for sugar beets, the roots which are not too seriously injured may put out new leaves and make some growth even after the tops are killed. *Rhizoctonia* may also produce irregular brown lesions on the beet roots. These occur



Figure 8. *Rhizoctonia* rot, surface view.

*Specific directions can be secured from the Botany and Bacteriology Department, Montana Agricultural Experiment Station, Bozeman, Montana.



Figure 9. *Rhizoctonia* rot, longitudinal section.

commonly near the crown region, but sometimes they may occur below the soil line.

The loss of beets due to rotting is always more serious on heavy soils with poor drainage than on light, well drained soils, as excessive moisture favors infection and development of the disease. Under Montana conditions *Rhizoctonia* rot of sugar beets has occurred only sporadically. It was often observed that this disease occurred most on beets in heavy, wet soil rich in organic matter.

Black scurf disease of potatoes is also caused by *Rhizoctonia*, but apparently by another species rather than that which causes root rot of sugar beets. Studies conducted in the rotations at the Huntley Field Station showed that in some of the rotations, potatoes were severely infected with *Rhizoctonia*, while succeeding sugar beets were free of this disease; therefore, sugar beets may safely follow potatoes in the rotations.

There are no satisfactory control measures for this disease. Improving the drainage of wet soil and crop rotations are beneficial.

Another type of *Rhizoctonia* root rot of sugar beets has been reported in Utah, in which case the sugar beet leaves wilt, turn yellow and die. This fungus produces brown lesions in the form of circular rings on the beet roots. These lesions become confluent, cover most of the beet roots, and plants succumb to the disease.

MISCELLANEOUS ROOT ROTS IN FIELD

Very often a considerable amount of damage to growing sugar beets is done by different soil fungi which cause rots of the lower parts of sugar beet roots. These root rots are predisposed by unfavorable nutritional and physical conditions of the soil and are usually abundant in heavy wet soils with poor drainage. Very often these rots are caused by the organisms (*Phoma*, *Rhizoctonia*, *Fusarium*, etc.) which are responsible for root rots of the beets in their seedling stage. After apparent recovery of sugar beets from seedling disease these organisms remain on the beets in more or less dormant stages. If the host plant is vigorous, these

parasites usually remain in a dormant stage and do not produce root rots, but if conditions of growth are poor and the beets are weak, these parasites may become active and cause further damage.

Conditions favoring vigorous and healthy growth of sugar beets are the best control method of these root rots.



Figure 10. Crown gall.

CROWN GALL

Crown gall is found occasionally in many beet fields, but rarely causes serious damage. Beet roots affected with crown gall are very conspicuous and usually attract the attention of the grower.

The bacterium (*Phytophthora tumefaciens* (Sm. and Towns.) Bergey et al.) enters wounds in roots caused by cultivation, blocking, etc. and forms a gall. The galls vary greatly in size from small ones less than $\frac{1}{2}$ -inch to large ones 3 or more inches in diameter (figure 10). The casual organism may live for many years in the soil, infecting a great many species of plants among which are raspberries, roses, apples, etc.

A long rotation including corn, small grains or grasses, will reduce the chances of infection by this organism.

HAIL DAMAGE

Hail storms frequently occur in the sugar beet-growing districts, doing more or less damage. The time of the season that a hailstorm occurs determines largely the amount of damage. If storms occur at about thinning time, severe damage often results since many of the young beets are killed. Hail later in the season only destroys the leaves and the root growth is checked until new leaves are formed. Sugar beets show a remarkable ability to recover from hail injury, and no other crop can compare with it in this respect. Sugar beets which have suffered injury from two or more hailstorms have produced a fair to good tonnage of beets.



Figure 11. Left, beet leaf showing normal venation. Right, beet leaf showing the transparent network of minute veins usually present on the youngest leaves of curly top beets.

(Courtesy Agricultural Experiment Station, University of California: from Bull. No. 465.)

CURLY TOP DISEASE

The curly top disease of sugar beets caused serious economic loss in the Western states for many years. There was no practical control of this disease until 1934 when the United States Department of Agriculture introduced a variety of sugar beets resistant to curly top. Since that time other resistant varieties have been introduced, so that a large part of the total acreage is now planted with resistant varieties, especially in the Western states where curly top was most severe.



Figure 12. Leaves from curly top beets showing left, small wart-like elevations on veins. Right, small wart-like protuberances limited to lower right side.

(Courtesy Agricultural Experiment Station, University of California: from Bull. No. 465.)

Curly top is caused by a virus that is carried by the leaf hopper (*Eutettix tenellus* Bak.). One of the earliest symptoms apparent is an inward rolling of the lower and outer margins of affected young leaves of the beet. In some cases the lower surface becomes roughened and shows conspicuous vein swellings (figures 11, 12 and 13). The diseased leaves are dark green, thick, crisp and brittle.

Affected roots often have an abnormally large number of lateral roots, which give a hairy appearance. A cross section of the roots show dark concentric rings alternating with light circular areas.

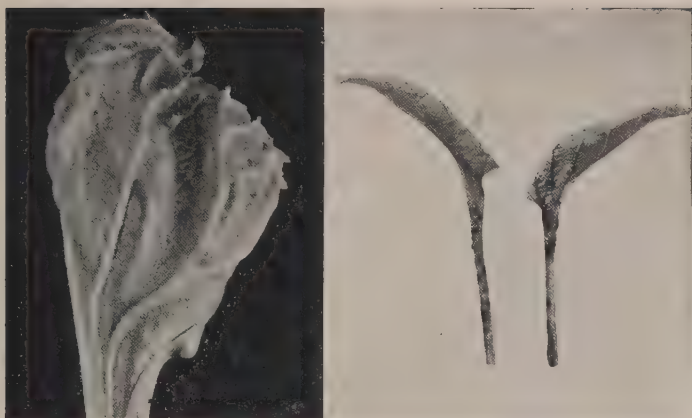


Figure 13. Leaves from curly top beets showing left, nipple-like papillae and knot-like swellings on distorted veins. Right, black liquid exudation on petiole and veins.

(Courtesy Agricultural Experiment Station, University of California; from Bull. No. 465.)

It is possible to produce a good crop of sugar beets, in spite of this disease, by using resistant varieties and adopting good cultural practices.

VIOLET ROOT ROT

This type of rot is caused by a soil fungus (*Rhizoctonia crocorum* (Pers.) D. C. (*Rhizoctonia violacea*)).

Beets infected with this fungus have their underground parts covered with a felt-like violet or purplish-colored fungus mycelium (figures 14 and 15). "Infection cushions" are formed where the mycelium comes in contact with the beet, and it is by means of these cushions that nutrients are transmitted from the host to the mycelium on the surface. When the growing plants are affected, the mycelium may spread from plant to plant. The fungus does not remain only on the surface of the beet, but penetrates the tissue and brings about the decay of the root. With the decaying of the root, the leaves die, so that where the attack is severe the beets die. Small reddish-violet sclerotia are formed by the mycelium on the surface of beet roots, and these serve as a means of carrying the fungus over adverse conditions, and give rise to mycelium again upon germination in the spring. This fungus also attacks a number of other plants, in particular alfalfa,

clover, carrots, asparagus, potatoes, etc., including numerous weeds. The fungus remains alive in the soil for a number of years.



Figure 14. Violet root rot, surface view.



Figure 15. Violet root rot, cut surface view.

In controlling this disease it is recommended that any crop that is susceptible to the disease should not be planted in infested soil until at least 4 years have elapsed. Loosening of soil by cultivation also helps in control. This disease is of minor importance in Montana.

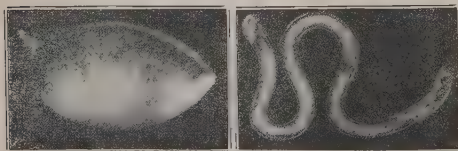


Figure 16. Female and male nematode (enlarged). (Courtesy of Great Western Sugar Company).

SUGAR BEET NEMATODE

The sugar beet nematode (*Heterodera Schachtii* Schmidt), one of the most destructive pests of the sugar beet, occurs in Montana. It is not generally distributed in the sugar beet-growing sections, therefore every recommended

method should be adopted to prevent infestation of non-infested fields. When a field becomes infested with nematodes it is practically impossible to eradicate them, so they remain as a continuous



Figure 17. Sugar beet showing female nematode attached to small lateral roots. (Courtesy Great Western Sugar Company.)

source of trouble.

The presence of nematodes can usually be determined by thoroughly inspecting the beet field during the summer when the beets are making a rapid growth. Plants attacked show a wilted condition and are, usually undersized. If plants showing these symptoms are found the beets should be carefully removed, care being taken not to destroy many rootlets. In case of infected beets, small, whitish lemon-shaped bodies (the adult female nematode) about $1/20$ inch in length can be seen attached to the rootlets (figures 16 and 17). Badly infested areas have poor stands of small, stunted beets of poor color. Nematodes attack the feeding roots and induce the production of a large number of fibrous roots, this condition being often referred to as "hairy root." (Figure 17).

The only known practical method of reducing nematode infestation is to have nematode-resistant crops for 4 or 5 years in a rotation. These crops include alfalfa, beans, peas, potatoes, small grains, and corn. In addition to growing resistant crops, susceptible weeds such as mustards, lambsquarter, knotweed, purslane, and curly dock must be eliminated from the cropped land. Only one crop of sugar beets should be grown in the rotation.

Nematodes often are introduced on non-infested land by the distribution of "dump" dirt, therefore "dump" dirt should not be returned to land which is to be used for growing sugar beets.

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